No. 6

Dam Safety Outlet

DAM SAFETY PROGRAM

September 2002

Montana Department of Natural Resources and Conservation

Rodent Hole Suspected Cause of Dam Failure in Garfield County

An irrigation dam in Garfield County failed on June 23, 2002. The dam was located on Taylor Creek approximately 22 miles southeast of Jordan, Montana. The estimated capacity of the dam when filled to the emergency spillway crest was 1,000 acre-feet. The height of the dam was approximately 32 feet.

Flash flood warnings had been issued the previous night, with a total of 3 to 5 inches of rainfall expected in Garfield County. At 6:00 a.m. on Sunday, June 23, the dam owner went to see how much water had accumulated in the large reservoir. When he arrived, water was running through the emergency spillway and leaking through a gopher hole on the embankment (near the top portion). The owner promptly called all of his downstream neighbors.

The water created a larger leak through this area and by 9:00 a.m. breached the embankment. There was no evidence of dam overtopping.

Fortunately, downstream damage was minimal. Several gravel roads were washed out. Damage also occurred to a bridge on U.S. Highway 200. The basement of one house downstream was flooded. The dam failure also reportedly caused downstream stock dams to break.

Taylor Creek Dam Failure - Photo by Candace Linder, NRCS

(Source: National Weather Service Report, Glasgow, Montana, U.S. Natural Resources and Conservation Service Engineering Trip Report, Glasgow, Montana)

Earthquake Ground-Shaking Map Developement

Earthquakes are capable of causing great damage to dams. Since Montana is one of the most seismically active states in the country, there is the potential to have a large earthquake of magnitude 7.0 or greater. Therefore, it is necessary to evaluate dams to see how resistant they are to damage and failure from ground shaking.

In order to do this, one must have an idea of what magnitude earthquake could occur in the area near the dam. In California, evidence of faulting is abundant, and determining a maximum earthquake is relatively straightforward. However, in Montana, in many instances there is little or no surface expression of a fault, for several reasons. First, Montana is recently glaciated and heavily forested in the western half of the state, which obscures the many surface expressions of ancient earthquakes. Second, many of Montana's earthquakes are smaller than magnitude 6.5, which usually will not produce a surface rupture. These are called "blind faults."

That is not to say that a magnitude 6.5 earthquake cannot cause extensive damage. For example, a series of earthquakes hit the Helena area in 1935, and the largest was a magnitude 6.0 event. The result was approximately $4 million in damage, four deaths, and several injuries. There is no evidence on the ground surface of the fault that caused this earthquake. It is believed however, that this fault is located directly beneath the city. If a similar earthquake were to occur today, it is estimated that there would be up to $60 million in damage and numerous fatalities.

Montana has many faults that haven't moved in recent geologic time. These faults are termed "inactive" and are not considered to be a threat to dams or other structures. Thus, finding evidence of a fault that generated a large earthquake in the past does not necessarily mean that one needs to be concerned.

One way of determining whether a structure could be exposed to excessive ground shaking is to conduct what is called a "probabilistic seismic hazard analysis." A probabilistic analysis uses relationships based on recorded ground motions, existing fault data, and historical earthquake records to determine the probability that a level of ground shaking will be exceeded at any particular point in the state. The analysis takes into account whether a fault is "active" and also accounts for "blind faults." This type of analysis seems most appropriate for Montana. A dam near a fault that hasn't moved in the last 2 million years should not have to be designed to the same level as a dam near the fault responsible for the famous Hebgen Lake earthquake in 1959. On the other hand, a dam that doesn't have mapped active faults nearby, but is in an area with a history of strong ground shaking (for example, Helena), should be designed to more stringent standards.

The U. S. Geological Survey (USGS) has developed probabilistic ground shaking maps for the western United States. These are being used very frequently in dam analysis. However, for Montana, these maps utilize only a fraction of the available data and are not sufficiently detailed. In addition, the USGS maps are applicable only for rock foundations. Because many of the state's dams are built on soil, the USGS maps are not adequate.

To provide engineers with accurate data for assessment of ground-shaking potential near a dam or other structure, DNRC requested funding from the Federal Emergency Management Agency (FEMA) to develop detailed ground-shaking maps specific to Montana. FEMA's contribution is $105,000. DNRC then contracted with URS Corporation of Oakland, California, to develop the maps. URS is one of the world leaders in

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Dam Trivia

Which Montana reservoir is the fifth largest in the United States, with a capacity of just over 22 million cubic meters?

FORT PECK LAKE

Spillways in Montana - Frequently Asked Questions

WHY IS IT ASSUMED THAT MY DAM WILL FAIL IF IT IS OVERTOPPED?

The Montana Department of Natural Resources and Conservation (DNRC) does in fact consider any overtopping of earth-filled dams to lead to dam failure. No matter how long, large, or well constructed a dam is, water tends to form a channel over the dam that then conveys a significant portion of the flow. This channel usually quickly erodes down to natural ground, completing dam failure.

DNRC does not consider overtopping of concrete and rock-filled dams to automatically cause dam failure. The amount of water that is allowable to overtop, and still meet the spillway standard, is dependent on the structural stability of the dam, abutments, and foundation.

IF A LARGE FLOOD IS OCCURRING ANYWAY, WHY WOULD FAILURE OF MY DAM MAKE ANY DIFFERENCE?

Dam failures result in very large floods. Most dams of any significant size that fail would result in floods well in excess of the 500-year flood. But, if the dam failure flood is calculated to cause no more deaths than the natural flood, the spillway size required by DNRC is less.

WOULDN'T PEOPLE SEE THE FLOW GOING OVER THE SPILLWAY AND SEEK HIGHER GROUND BEFORE DAM FAILURE?

Psychologically, dams often result in the reverse. Often the reservoir will first dampen the flood downstream. People feel secure, knowing that there is a dam upstream storing the flood. Once overtopping and dam failure occur, the flood wave often comes quickly and without warning. This flow can then be more than 100 times the flow they experienced moments before.

DOES MY DAM NEED TO CONVEY THE PROBABLE MAXIMUM FLOOD (PMF), AND WHAT THE HECK IS THE "PMF"?

Under our Montana rules, which were changed in 1999, your dam is no longer required to handle the PMF. This flood is based on extreme meteorological conditions all happening at the same time. In essence, it is the largest flood that could occur.

SO, HOW BIG DOES MY SPILLWAY NEED TO BE?

The size of your spillway is based on the estimated loss of life downstream that would occur if your dam were to fail. For example, if it is estimated that one life would be lost due to dam failure, the spillway would need to convey the 1,000-year flood. If three lives would be lost, the spillway would need to convey the 3,000-year flood.

A 3,000-YEAR SPILLWAY? ARE YOU TELLING ME THAT I NEED TO BUILD A SPILLWAY FOR A FLOOD THAT OCCURRED 1,000 YEARS BEFORE THE BIRTH OF CHRIST?

Unfortunately, this prevalent feeling is a result of scientific terminology being unnecessarily complicated. Basically, a 3,000-year flood is a flood that has a 1-in -3,000 chance of occurring each year. This is the same probability of an individual being in a fatal car accident each year. Over a 50-year period of our life, there is a 1.5 percent chance of death in a fatal car accident or the occurrence of a 3,000-year flood.

OKAY, I READ ABOUT PEOPLE DYING IN CAR ACCIDENTS ALL THE TIME. WHY DON'T I HEAR ABOUT DAM FAILURES?

First, there are far more drivers than there are dams. Second, weather is cyclic. If there is a weather-caused dam failure, there would be a good chance of having additional dams fail from the same storm. For example, during this year, there were at least three dam failures in north-central Montana during the month of June. Fortunately, populations there are small, and no lives were lost.

CAN YOU REALLY TELL WHAT THE LOSS OF LIFE IS GOING TO BE IF A DAM WERE TO FAIL?

No. Really all we can do is make an estimate. The conditions that are in place during a dam failure are often variable. For example, does the failure occur at night when everyone is home sleeping, or does the failure occur on a weekend

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EAP Exercise Success

State law requires that emergency action plans (EAPs) be updated on an annual basis for all high hazard dams regulated by DNRC. In addition, frequent tests are recommended to verify workability of the plans. For testing, the state-regulated high hazard dams are given a priority ranking based on physical condition and downstream population.

Tom Sanburg has been working for two years as an EAP coordinator for the DNRC Water Operations Bureau. When a dam is selected for an EAP exercise, Tom reviews the EAP to ensure that it is up-to-date and in a usable format. He then assembles an exercise design team including the dam owner, one dam safety engineer, and the local Disaster and Emergency Services coordinator. This team decides on when and where to conduct the tabletop exercise and what type of dam failure scenario to use.

Once these details are decided, Tom can go to work making exercise messages and visual aids for the exercise. Tom invites pertinent volunteer organizations, residents, and other government agencies.

The day of the exercise is fun for all who participate. A tabletop exercise is held in an informal seminar setting and lasts for about four hours.

EAP tabletop exercise for Mill Lake Dam, Hamilton, Montana, 2002.

Lunch (usually pizza) is served during the exercise. Participants receive challenging messages, which are openly discussed. This is a very good opportunity for participants to become familiar with each other, as well as with the emergency response process. The tabletop format allows for a "stop-and-go" training method, i.e., if someone answers incorrectly or is stumped by a problem, the exercise can be stopped until clarification is obtained. The time line can then be shortened or stretched to meet the day's training objectives. At the end of the session, participants discuss ways to improve the EAP and complete a written review of the exercise.

To date, Tom has completed nine EAP exercises. Feedback from dam owners and participants has been very positive. Many have suggested holding exercises for their dams on an annual or biannual basis.

If you are interested in holding an exercise to verify your dam's EAP, call Tom at (406) 444-9362 or e-mail tosanburg@state.mt.us.

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when the campground downstream is full? Obviously, a great deal of judgment is used.

The one principle that is applied is that not all people flooded will lose their life. In fact, only a small percentage of the people that are flooded in low force (low water speed) areas are estimated to be casualties. Even in high force areas (high water speed), it is expected that some people would be able to survive.

WHAT HAS BEEN THE OVERALL RESPONSE TO THE NEW SPILLWAY STANDARDS?

Although most dam owners have seen their spillway requirement lessened considerably since 1999, the use of terminology like "5,000-year flood" has raised eyebrows. Again, we need to put man-made structures in perspective. The annual risk of dying in a commercial aircraft accident is 1 in 700,000. Is a 1-in-5,000 risk for the loss of five lives overly conservative?

The only state that has a spillway standard known to be easier to meet is Wisconsin. Compared to most states, our standard is not overly restrictive to dam owners. This does not mean that the issue cannot be revisited, if the dam owners feel it is necessary.

THE Dam News

FROM AROUND THE STATE

CARBONE DAM CONSTRUCTION

A new dam was recently built in Bighorn County near Decker, Montana. Carbone Dam is owned by Spring Creek Coal Company and serves to protect its open pit coal mining operation from storm water inflows. The earthen dam is 31 feet in height and has a crest length of 2,800 feet. Nearly 375,000 cubic yards of material was moved during construction. The dam outlet utilizes a HDPE plastic pipe 18 inches in diameter and 260 feet in length. An upstream slide gate operated from the crest by a hand wheel provides control of the outlet. Because the dam serves the critical role of protecting workers immediately downstream, the dam is classified as "high hazard." Design and construction management were provided by Western Water Consultants, Inc., of Sheridan, Wyoming. The Montana Dam Safety Program provided design review and assisted the owner and engineer in complying with state dam safety requirements.

BAIR DAM

Bair Dam is in Meagher County and is located 20 miles east of White Sulphur Springs. Immediately downstream of the dam is the small town of Checkerboard. The dam and reservoir are easily visible from U.S. Highway 12. Rehabilitation construction is being completed from 2001 to 2002. During the fall of 2001, excavation for a new spillway was begun. Finished construction for 2001 included drains, a new outlet terminal structure, and a toe berm. Construction proceeding this year includes a new concrete spillway, access roads, and a 3-foot embankment raise. Wickens Construction, of Lewistown, was the contractor for the 2001 construction. Dick Anderson Construction, of Helena, is contracting this year's work. Design was completed by HKM Engineering. The total cost of the project is estimated to be $2 million. The Upper Musselshell Water Users Association will pay approximately $1 million. The remaining funds are provided from various state sources including earnings from the Broadwater hydropower project and a Renewable Resources Grant from the Coal Severance Tax Trust Fund.

SOUTH HILLS STORM WATER RETENTION PONDS

The City of Missoula is in the process of constructing a new flood control reservoir. The new reservoir is part of a much larger mitigation project involving a residential area that has frequently been flooded in the past. When the project is complete, numerous homeowners will no longer be in the 100-year floodplain of Pattee Creek. There will be cost savings on several fronts: not only will damage from flooding be eliminated, but also the homeowners will no longer be required to obtain flood insurance.

The reservoir itself is very unique. The reservoir bottom functions primarily as a baseball field, and secondarily as a flood control basin. In addition, the reservoir is designed to not hold water. Once floodwaters enter the basin, they should quickly seep into the gravelly soils of the area. Due to the potential for loss of life in the surrounding residential area when the reservoir is full, the dam is classified as high hazard, and it is subject to the permitting requirements of the Dam Safety Program. The engineer on the project is WGM Associates of Missoula. The project will be completed in the fall of 2002.

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seismic hazard analysis. Assisting with the project are representatives from the Montana Bureau of Mines and Geology, Montana Tech of the University of Montana, the U.S. Bureau of Reclamation, Montana State University, and FEMA.

It is anticipated that the maps will be made available in the summer of 2003. The maps will be available either in hard copy or electronically. In addition, URS will be putting on a training seminar on proper use of the maps. The maps will be of value not only for analyzing dams, but also buildings, landfills, interstate bridges, and any other structure that could be adversely affected by an earthquake.

For more information on the status of the map development, please contact Michele Lemieux, DNRC Dam Safety Program Manager, at (406) 444-6613.

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NEVADA CREEK DAM

Nevada Creek Dam is in Powell County and is located 20 miles northwest of Avon. The dam and reservoir are easily visible from State Route 141. Rehabilitation construction is being completed from 2002 through 2003. Work this year will include an outlet extension, materials processing, toe berm, drain system, and dewatering wells. Next year's work will be the construction of a new concrete spillway. Smith Contracting, of Butte, is the contractor for this year's construction. HKM Engineering completed the design. The total cost of the project is estimated to be $3 million. The Nevada Creek Water Users Association will pay approximately $500,000. The remaining funds are provided from various state sources including earnings from the Broadwater hydropower project, the DNRC Water Storage Account, and a Renewable Resources Grant from the Coal Severance Tax Trust Fund.

Inside this Issue.....

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